

# Contemporary Smile Design: An Orthodontic Perspective



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## KEYWORDS

- Smile esthetics • Smile design • Orthodontic appliances • 3D imaging
- Orthodontic aligners and customized 3D appliances for orthodontics

## KEY POINTS

- The use of 3D technology for records and diagnostic planning.
- Bracket placement for optimum smile design.
- Aligner treatment during orthodontic treatment.
- Surgical interventions for orthodontic smile design.
- TADs for orthodontic tooth movement and tooth control.

## INTRODUCTION

Orthodontists make a huge impact on the lives of people seeking better smiles. Although there are various reasons why people seek orthodontic care, one of the reasons is the ability of orthodontists to convert a malocclusion into well-balanced, pleasing, and artistic appearance of teeth within the smile framework. With this end point in mind, the goal of the orthodontist is to evaluate how a smile will fit into the facial morphology of any given individual.

In this new age of selfies and social media boom, laypeople have started noticing even the slightest asymmetries noticeable in the past only to clinicians. How a smile can be crafted into an individual's face with harmony and balance is truly important. Unconsciously, smiling is the most important nonverbal way of communication and perception. It is by far the most effective way to express emotions and create connections.<sup>1,2</sup> Every individual carries a unique smile to their face, and there is no perfect recipe for a smile. However, over the years, many studies have been published discussing the parameters involved in creating a perfect smile.<sup>3,4</sup> The goal of orthodontic treatment should be to achieve a smile that is in harmony with the face.<sup>5</sup>

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Dent Clin N Am 66 (2022) 459–475

<https://doi.org/10.1016/j.cden.2022.02.007>

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## ***Esthetics of a Smile***

In the past, many orthodontists focused on the function and ideal rehabilitation of the dental malocclusion. In recent times, it has been found that despite attempts to finish to an ideal dental occlusion, the perception of the smile was found to be less than perfect. In fact, a recent study found that of the 68 occlusal finishes for the American Board of Orthodontics examination, only 2 of the finished results were deemed to have a perfect smile by a panel of judges.<sup>6</sup> This same sample was further validated by a panel of judges of different ethnic background, and similar results were achieved.<sup>7</sup> These findings reexamined the occlusal goals of treatment and highlighted the perceptive effect that needs to be brought about during treatment.

Although many analyses and many studies have discussed the variables that define a good smile, it is universally accepted that the following components are important: (1) smile arc projection,<sup>8</sup> buccal corridor display,<sup>9</sup> and amount of gingival exposure at smiling<sup>10</sup>; (2) presence of gingival and incisal asymmetry<sup>11</sup>; (3) presence of midline shift and changes in axial proclination<sup>11</sup>; and (4) maxillary incisors ratio, size, and symmetry.<sup>12</sup>

Vertical positioning of the upper incisors helps in achieving a younger and dynamic smile. The incisal edge of maxillary central incisors must be below the cuspid tip of canines, ensuring dominance of the central incisors.<sup>13</sup> The step between central and lateral incisors should range from 1.0 to 1.5 mm for women and from 0.5 to 1.0 mm for men.<sup>13</sup>

How a smile is viewed is also important. For example, when viewing from frontal photographs, the downward positioning of maxillary plane and head inclination can lead to greater exposure of the incisors. On the other hand, upward positioning of the maxillary plane and head inclination can lead to less exposure of the upper incisors thereby hindering the original smile.<sup>14</sup> On smiling, the width and height ratios for the maxillary central incisors should be 75% to 85%.<sup>15</sup> Symmetric incisal edges are also very important in keeping good esthetics. If the lateral incisors are too narrow or thin, interdisciplinary treatment options should be considered. Slightest gaps in the frontal esthetic zone can be displeasing to look at, and all dental spacing should be closed. Any deviation of the midline equivalent to 2 mm or greater should be addressed clinically. One great way to avoid or eliminate black areas is maintaining tight contacts, modifying contact areas, and increasing the surface areas of the connectors.<sup>11</sup>

Many orthodontists attempt to categorize the smile into components that can be addressed. In general, the smile is made up of 3 components.

### ***Gingival component***

This component consists of 4 elements: the texture, the color, the shape, and the amount that shows on smiling. A healthy gingiva is stippled and firm, normally coral pink, but the color depends on the amount of pigmentations and the race of the subject. The ideal location of the gingiva is 3 mm above the alveolar bone crest (facially) assuring the gingival margin of the central incisor is on the same level as the canine's margin, and slightly higher than the one of the lateral incisors, with the zenith slightly to the distal of the crown's long axis of the central incisor and canine and on the long axis of the lateral incisor.<sup>13</sup> Also, the dental papilla normally should fill the interdental space showing no "black triangles"; furthermore, according to Kokich and colleagues<sup>16</sup> up to 3 mm of gingival height that shows on smile is considered acceptable.

### ***Dental component***

This component consists of 5 elements: the color, the shape, the size, the position, and the alignment.

Any decalcification, interior or exterior staining, can affect the teeth color and ultimately affect the smile esthetic because, from the patient perspective, the teeth color is one of the most important factors in smile attractiveness.<sup>17,18</sup> According to Heravi and colleagues,<sup>19</sup> the teeth shape is an essential element in creating a charming smile; people prefer the round shape compared with the triangular and square incisors. In addition, the size of the teeth was proved to be important<sup>20</sup>: lateral incisor size, width to height ratio, and the crown size proportion of the anterior teeth.<sup>21,22</sup> Furthermore, the position of the anterior teeth in the 3D space is fundamental in designing a charming smile; vertically, the upper anterior teeth incisal edges are supposed to be in harmony with the curvature of the lower lip with ideally full exposure upon smiling.<sup>2,4,23</sup> However, transversely, perfect alignment with no rotations, no spacing, and with the upper dental midline coinciding with the midsagittal plane represents the optimal situation. Nonetheless, Bhuvanewaran<sup>24</sup> mentions that a discrepancy up to 2 mm was unnoticeable from laypeople as long as the contact line between the upper central incisors is parallel to the facial midline. Last, the sagittal position and inclination of the upper front teeth is a major component in providing an adequate anterior guidance, providing anterior teeth exposure, and ensuring good lip support that is essential for smile esthetic.

### **Soft tissue component**

The lips are the frame of the smile: their position, the curvature, and their thickness are vital elements for a pleasant smile. The upper lip position can be optimal showing the full crown length of upper teeth; high, revealing more than 2 mm of gingival display; or low, exposing less than 70% of the upper central incisors. Also, the curvature and the symmetry of the upper lip were found to be important parts of the smile<sup>25</sup>; they depend primarily on neuromuscular factors. Last, the thickness of the upper lip seems to have significant influence on the overall smile attractiveness.<sup>26</sup>

In summary, smile design must encompass not only straight teeth but also other factors that include size, color, gingival display, and smile drape.<sup>6,7</sup>

### **Clinical Care Points: Role of the Orthodontist**

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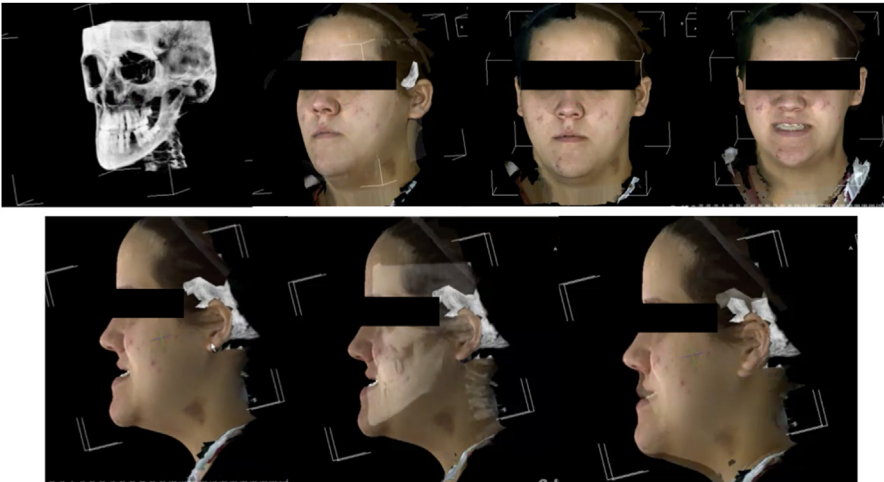
The orthodontist's role in smile design takes several forms. The following key points are important for the orthodontist to pay attention to.

#### **Using technology to capture diagnostic records of the patient**

Many tools are available for orthodontists to capture the smile. Static 2D records consisting of pictures, study models, and radiographs are the mainstay of the initial record.<sup>27</sup> These records should be collated into a standard composite layout for easy evaluation and treatment planning. Once these pictures are captured, a goal-oriented method can carefully map out to complete the end goal of the treatment plan (**Fig. 1**). In recent years, 3D technology has helped to create spatial awareness of the skeletal structures and relationship of teeth.<sup>28</sup> These technologies create true visualization of the limits of tooth movement with the frame of the jaws.<sup>29</sup> Newer and exciting innovations archive the 3D virtual patient effectively<sup>30,31</sup> and simulate smile and lip movements of the soft tissue (**Fig. 2**). Surgical interventions and surgical simulation create predictable and enhanced communications between surgeons and orthodontists.<sup>32–35</sup> Even more advanced technologies have also incorporated the movement of the jaws in real time hence redefining dynamic positioning of the condyle and centric relation.<sup>36,37</sup> Finally, 3D customized appliances are now readily available to deliver the ideal treatment plan and position the teeth accurately in the smile framework (**Fig. 3**).



**Fig. 1.** Nine Composite pictures depicting the 2 dimensions of the patient's facial, smile balance, and teeth. The goals of treatment are (1) smile design within the face, (2) molar relationship, (3) alignment and (4) rotational control of teeth, (5) overbite, (6) overjet, (7) inclination, and (8) angulation of teeth and cusp to fossa interdigitation.



**Fig. 2.** 3D Imaging: A combination of surface scanning of the photographic face (in static and on smiling) and the traditional cone beam imaging technology. The 3D pictures were captured by a 3dMD Camera (3dMD LLC, Atlanta, Georgia, USA), and the Cone Beam Computed tomographies (CBCTs) are from the Carestream 9500 (Carestream, Atlanta, GA, USA) machine. These 2 types of imaging technologies are carefully combined using the 3D Vultus software (3dMD LLC, Atlanta, GA, USA). The images show that the soft tissue significantly masks the underlying skeletal structures and also depict the dynamic impact of the musculature of the smile.



**Fig. 3.** 3D customized appliances by KL Owen Braces (KLOWen Braces, Austin, TX, USA). The exact position of the brackets is prescribed onto the 3D rendering to produce the desired alignment and esthetic results. Once the brackets have been set 3 dimensionally, a rubber-based transfer jig is used to indirectly bond the brackets onto the teeth. This case shows a Class IID2 malocclusion with one lower incisor missing. The treatment using customized braces took only 4 visits to complete.

### ***Managing the gummy smile on patient with excessive gingival display***

The amount of gingival display affects the perception of a smile.<sup>6,7</sup> There are several reasons for excessive gingival display or gummy smile. These reasons include the overgrowth of gingiva, supraeruption of upper incisors, and vertical maxillary excess. The orthodontists with the help of other dental specialties can significantly improve the gummy smile of an individual. A variety of procedures can be performed orthodontically and surgically. Gummy displays may be managed in the following 3 ways:

1. Displays within 2 to 4 mm may be managed by intruding the teeth orthodontically, crown lengthening, or Botox.
2. Displays of 4 to 8 mm may be treated by lip stabilization, or surgery can be considered.
3. Displays of more than 8 mm need to be managed with surgery alone.

**Surgical management.** Broadly speaking, highly distinguished or excessive gummy smiles are the result of vertical maxillary excess.<sup>38,39</sup> The cause of the gummy smile should first be identified as skeletal, dentoalveolar, or musculature. If a skeletal disproportion exists, the Le Fort 1 osteotomy can help reduce the maxillary excess (Fig. 4); it decreases the vertical skeletal length of the maxilla thereby decreasing the amount of gingiva show. These surgeries are performed under general anesthesia, and the cuts are done inside the mouth. A wedge of bone that coincides with the vertical excess is removed. These procedures must be carefully planned and facial balanced achieved



**Fig. 4.** Gummy smiles with more than 8 mm gingival excess for both sets of patients. Each patient received surgical vertical impactions of the maxilla up to 6 to 8 mm. The resultant smile within the smile framework was greatly improved.

to reduce unwanted facial results.<sup>40</sup> There is often a limit to the amount of bone that can be removed.

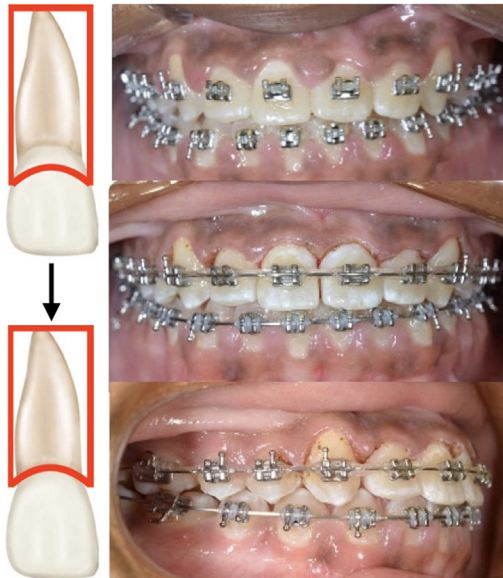
**Botulinum type A toxin (Botox).** Botulinum type A toxin (Botox) has been used in reducing the hypermobility of muscles and soft tissues associated with smiles having excessive gingival display.<sup>41</sup> This procedure is carried out when the muscles of the smile are overretracted. The goal of this treatment is to reduce the hyperactivity of the muscles thereby reducing the extent of the smile drape and also the gingival display. Some investigators describe measuring the length between the lower margin of upper lip and the gingival margin of upper central incisor and have seen noticeable change after using Botox. This simple procedure can be done by an orthodontist, and normally 2.5 U per 0.1 mL is injected in 2 sites on each side of the face. These points coincide anatomically with the levator labii superioris alaeque nasi, levator labii superioris (LLS), and the LLS and zygomaticus minor muscle meeting on right and left sides of the face. The Botox injection weakens the ability of the muscles to contract thus reducing the hypercontraction, which leads to lesser pull of the lip while smiling. If Botox

is considered to treat the excessive gingival display due to the contraction of muscles, there should be a minimum 5 mm of gingival display to achieve pleasing results. The effects may not be long lasting, and the procedure is repeated throughout life.

**Gingivectomy or apical reposition flaps.** When gingival tissues are overgrown, hyperplastic, or inflamed, it creates an unesthetic appearance of the gingiva; it may also affect the ability of the patient to keep good oral hygiene. Overgrowth of gingiva in such cases can lead to a gummy smile, which if not treated in conjunction with orthodontics, can lead to poor esthetics results. Many orthodontists prefer to perform gingivectomies themselves because it saves chair time and saves on costs for the patient. The main aim is to remove excess gingival tissue, expose the underlying tooth, and create proper gingival contours. One should always be careful not to invade the natural biological width while carrying out these procedures. Gingivectomies are always preferred when there is excess amount of keratinized tissue, and the bone levels are within normal limits (Fig. 5). Care should be taken while taking out extra tissue only to achieve good esthetic results.<sup>42</sup> Apically positioned flap surgeries are performed when the gingivectomies do not suffice and are carried out in 2 scenarios: first, when the distance between CEJ and alveolar crest is normal and there is normal amount of keratinized tissue, and second, when the bone and CEJ are at same level and the keratinized tissue is within normal limits, in which case apical position flap with osseous reduction is preferred.<sup>43</sup> These procedures are often done by the periodontists or oral surgeons.

### ***Orthodontic Strategies for Fixed Appliances***

The mainstay in orthodontic treatment is the orthodontic bracket and wire. Each set of brackets is made up of a preadjusted system that has prescribed, or custom, 3D



**Fig. 5.** Gingivectomies performed with a simple soft tissue diode laser. The goal is not to invade the biological width but at the same time exposing as much of the clinical crown as possible.

values embedded within each bracket. An orthodontic wire is placed onto the bracket slot, and the 3D angles are expressed when the bracket slot is fully expressed thereby resulting in a pleasing result for both the occlusion and smile. Traditionally, the basic goal for the placement of the brackets is the center of the clinical crown and along the long axis of the tooth. However, careful manipulation during bracket placement on the tooth can alter the tooth position and enhance the smile.

***Deliberate apical positioning of the anterior orthodontic brackets***

Placing brackets gingivally has been advocated by the authors and others. This simple but deliberate placement of the bracket can help to develop the smile arc that maximizes the smile within the face<sup>1,3</sup> (Fig. 6). Often, during the planning stage, the maxillary arch wire plane is planned to be parallel to the upper lip, whereas the lower lip defines the incisal edges of the upper incisors. The difference in bracket placement heights in anterior and posteriors enables the maxillary cant to increase with respect to the true smiling plane. The gingival position of the brackets produces a clockwise rotation of the anterior segment via extrusion of the upper anterior when compared with the upper premolars.<sup>44</sup> Bite turbos and very light elastics can help in uprighting the teeth in the initial phase on light wires.<sup>45</sup>



**Fig. 6.** Selective apical position of the orthodontic brackets allows for smile arc development. A patient who initially presented with a reverse smile arch and proclined teeth developed a final result in which a consonant smile and upright teeth are achieved.



### ***Torque control (low torque)***

A recent study has shown that the maxillary incisor can change significantly in nonextraction class I, II, and III dental malocclusions. The findings showed that in class I and III malocclusions, the incisors are proclined or tipped forward, and in class II malocclusions the teeth are more upright at the end of treatment.<sup>46</sup> At present, nonextraction treatment is a popular choice among patients. However, in most of these cases, the maxillary incisors are proclined and crowding is present. To counteract the unwanted flaring of the teeth, which flattens the smile, placing the brackets more gingivally on the tooth surface helps in reducing the torque that is built in the bracket. The flaring of upper incisors can also be prevented by flipping the brackets 180° on the intended tooth surface.

### ***Interproximal reduction or addition of tooth structure***

Interproximal reduction (IPR) involves deliberate removal of enamel from the contact areas of adjacent teeth. This technique creates space to allow teeth movement and allow patients to avoid extractions. IPR is done by using diamond disks, metal strips, or burs. IPR leads to changes in the size of teeth and sometimes increases tooth stability after completion of treatment. IPR can also eliminate black triangles that sometimes form due to horizontal bone loss or narrow contact areas. In other instances, where teeth are too small, careful addition of tooth-colored composites can also guide the clinician through the process of smile design. A combination of either one or both is required to produce a pleasing smile (Fig. 7).

### ***Smile Design with Aligners***

Today, plastic aligners are a mainstay of orthodontic treatment. Clinicians are now able to truly design the smile in real time and to deliver optimum orthodontic results in a predictable manner. Once the teeth have been scanned by an intraoral scanner, the teeth may be visualized in 3 dimensions and carefully manipulated to achieve the



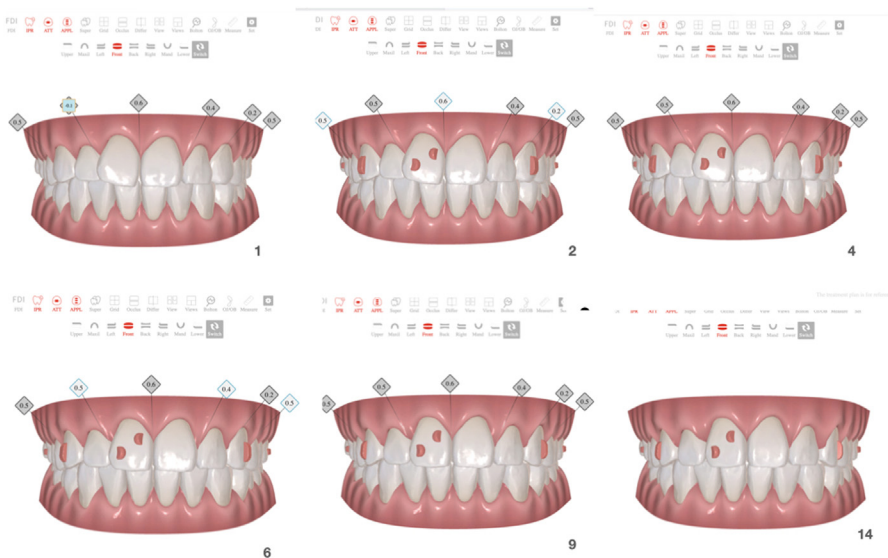
**Fig. 7.** Careful buildup and selective IPR of the anterior zone of teeth by the author (C.H.K.). This simple and effective process helps to guide the clinician in the management of the smile zone and careful smile design of the individual patient.

desired occlusion. This visual map of teeth can also help the patient gain the idea of what to expect. Modifications/customizations of tooth size, tooth movement, and final positions can be made unique to each tooth. Diagnosis and treatment planning for a pleasing smile is made easy through 3D visualization. Mock treatment plans help the orthodontist to make decisions and experiment with various treatment plans without actually delivering the appliances to the patient (Figs. 8 and 9). Once the desired treatment plan is agreed upon, the aligners are fabricated by the companies and shipped to the orthodontic practices or sometimes directly to patient. In the subsequent visits to the clinic, orthodontist carefully monitors the progression of plastic aligner therapy and each aligner is worn for 20 to 22 hours per day for up to 10 days. The tight fit of the aligner around each allows the plastic to place the desired pressure on the biological system remodeling bone and creating the desired tooth movements. When more complex tooth movements are required, clear composite tooth material is placed to act as an attachment so that the plastic aligners can have a better “grip” to bring about tooth movement.

### ***Peg Lateral or Missing Lateral: Buildup or Canine Substitution***

The treatment of patients with missing lateral incisors is often a multidisciplinary dental specialty approach; it involves orthodontics, esthetic dentistry, implantology, and prosthodontics. The team approach ensures that an optimal occlusion along with a well-balanced stable natural smile is achieved.

In the anterior smiling zone, there are various treatment options. In fact, there are 3 different options to manage the missing lateral incisors. These options include canine substitution, a tooth-supported restoration, and a single tooth implant. All options



**Fig. 8.** An example of a computer-generated representation of tooth movements. The dentition was captured by the iTero intraoral scanner (Align Technology, San Jose, California) and uploaded as a stereolithography model into the aligner software (Smartee Systems, Shanghai, China). A total of 14 aligners were required to bring about tooth movement and tooth alignment. IPR and composite attachments are also prescribed during treatment sequence.



**Fig. 9.** Smile design using Invisalign software (Align Technology, San Jose, CA, USA). The initial and final 3D rendering are seen together with the before and after smiles of the patient. The effective delivery of the treatment plan with plastic aligners has made these aligner systems popular among patients.

should be thoroughly discussed with the patient and/or parents, and the advantages and disadvantages of each treatment option should be explained.<sup>47–49</sup> The main objective of treatment planning should be tooth conservation wherein the least invasive option that satisfies the expected esthetic and functional objectives is prescribed.<sup>50</sup> Various factors should be considered by an orthodontist while treatment planning. We discuss the canine substitution and tooth-supported restoration for the treatment of missing lateral incisors.

### **Canine substitution**

The most appropriate patient for this procedure has an Angle class II malocclusion with no crowding in the mandibular arch, has a class II molar relationship with canines in traditional position, or has Angle class I malocclusion with sufficient crowding to necessitate mandibular extractions. By substituting the canines, the final result will



**Fig. 10.** Canine substitution with anterior TAD support (Ormco VectroTAS System, Drea, CA, USA).

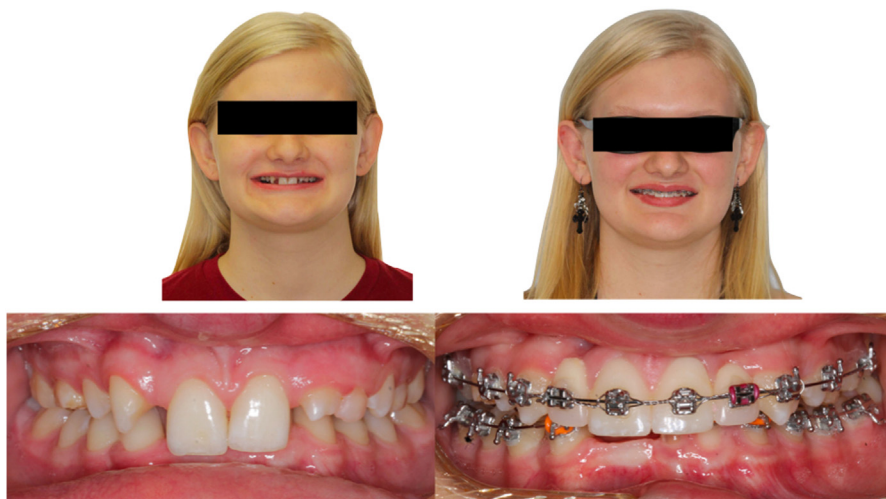
require the premolars take the load of the chewing cycle, and therefore the resulting occlusal scheme should be “group” function. As orthodontists the shape and color of the canine are also important esthetic factors for consideration. While reducing the canine to re-create normal lateral contours, clinicians also need to prevent of dentine or pulpal exposure.

To correct the color difference, bleaching the canine may be done failing which a veneer can be placed. The crown width at the CEJ should be evaluated on a pretreatment radiograph to help determine the final emergence profile, and the gingival margin of the natural canine should be positioned slightly incisal to the central incisor gingival margin. Simple gingivectomies described previously can also be done to achieve this. Proper bracket placement is important too if regular braces are used. Each bracket should be placed according to the gingival margin height rather than incisal edge or cusp tip. After the teeth have been aligned, restorative treatment may be needed to re-create an ideal lateral incisor color and contour. If these steps are followed, satisfactory esthetic outcomes can be achieved without causing functional problems to arise within the temporomandibular joint and allows periodontal health conditions to be better maintained (Fig. 10).

### ***Tooth-supported restoration***

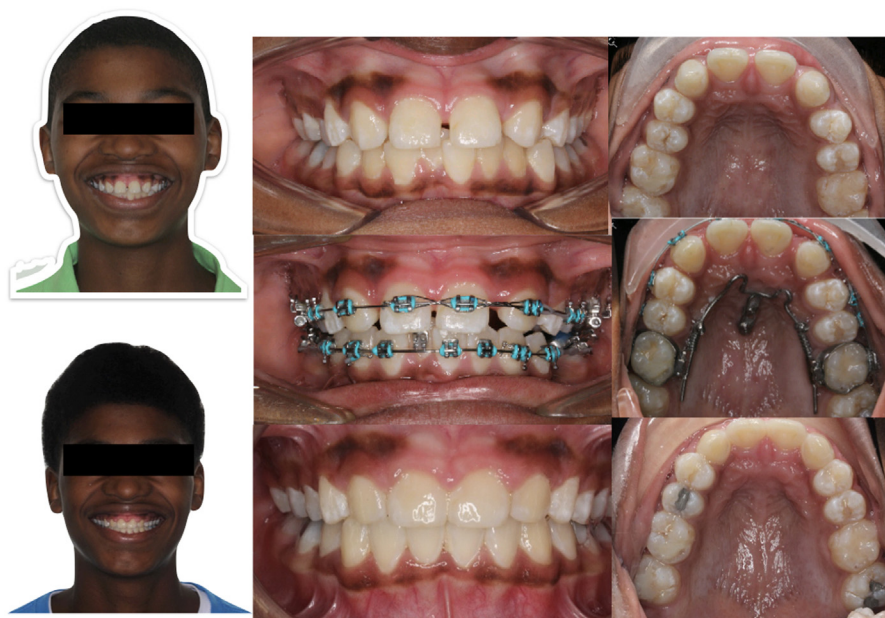
When the goal is to restore the missing or small teeth, tooth-supported restorations are considered. The primary types of tooth-supported restorations are resin-bonded fixed partial denture, a cantilevered-fixed partial denture, and a conventional full coverage fixed partial denture. The main objective while treating a peg-shaped lateral by the restorative treatment options should be tooth conservation, to achieve predictable esthetics, function, and longevity.<sup>40</sup> Again, the planning and execution involves a multidisciplinary approach to treat such cases. Thorough discussion of the case of missing maxillary lateral incisor or the presence of a peg-shaped lateral incisor should be done by an orthodontist with a restorative dentist before starting the treatment.<sup>48</sup>

The orthodontist plays an important role to determine and establish space requirements for patients with missing maxillary lateral incisor. The various methods to



**Fig. 11.** Lateral incisors buildup using denture teeth attached to orthodontic archwires. The plastic pontic teeth are attached to regular orthodontic brackets and mounted onto a regular archwire. Ligation tie wires are used to secure the brackets and prevent unwanted movement of teeth.

determine this are the golden proportion, using the contralateral lateral incisor as a guide, or to conduct a Bolton analysis. In some cases in which there is a bilateral involvement of 2 missing lateral incisors, the use of denture pontic teeth can be extremely useful (Fig. 11). In complex cases, a diagnostic wax up is the most predictable guide for determining ideal space.<sup>48</sup>



**Fig. 12.** Canine substitution with posterior TAD support. The TAD system used is the BENEFIT System (PSM Medical Solutions, Gunnigen, Germany) developed by Dr Benedict Wilmes.<sup>53</sup>

### ***Control of Torque for Facial Balance: Protraction with Temporary Anchorage Devices or Retraction with Temporary Anchorage Devices***

The application of temporary anchorage devices (TADs) is well known for its effectiveness in the intrusion, extrusion, protraction, and retraction of the anterior or posterior teeth.<sup>51</sup> Orthodontists mostly plan treatment involving closing or opening of spaces. Sometimes to do so, some form of rigid anchor is required, and TADs have become increasingly popular and are often indicated.<sup>47–49</sup>

TADs allow movement of teeth that require heavy anchorage with the orthodontic biomechanical system. If TADs are placed posterior and bilaterally on each side, this ensures the line of action of force passes through the center of resistance of the anterior teeth; this allows teeth intrusion or distal movement of teeth.<sup>52</sup> TADs placed in the interdental bone between the maxillary first molar and second premolar prove to be efficient for intraoral anchorage reinforcements for en masse retraction and intrusion of the maxillary anterior teeth. The vertical position of the TADs plays a characterizing job in coordinating the forces applied in intruding and extruding the anterior teeth. The forces did not gather at a single point and were distributed in root areas of teeth because of the group movement of teeth. This, along with the way that spaces distal to the lateral incisors that are obvious after individual canine retraction never show up with en masse retraction incredibly upgrades patient collaboration and inspiration. The TADs are put in the interdental bone between the maxillary first molar and second premolar and end up being productive for intraoral anchorage fortifications for en masse retraction and intrusion of the maxillary front teeth. In some instances, TADs may also be placed in the palate and hence do interfere with tooth movement within the arch (**Fig. 12**).

#### **SUMMARY**

Orthodontists play a vital role in the smile design of individuals. There are a variety of orthodontic goals and tooth movements that can be achieved to obtain the ideal smile that ultimately leads to the optimum esthetic outcomes. In this article, some methods and appliance systems to control and achieve the desired tooth movements are described and illustrated.

#### **DISCLOSURE**

The authors do not have financial or commercial conflicts of interest when writing this article. The authors have not used any funding source or grant agency in the preparation of the manuscript.

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